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# Redesigning Processes for Decision-Awareness: Strategies for Integrated Modelling

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**Abstract**—The integration of decisions into processes has seen a surging interest in literature since the introduction of the Decision Model and Notation (DMN) by the Object Management Group (OMG) in 2015. The DMN standard has successfully been adopted in both industry and academia, as it provides a suitable approach towards filling the void of decision representation in the field of Business Process Management (BPM). Although a number of approaches exist in literature on how to build DMN models, or on how to extract DMN models from process models, no clear modelling strategies have been presented to introduce decision-awareness into existing processes. This paper discusses strategies for integrated process and decision modelling, as well as their implications for process redesign in order to render processes decision-aware. The modelling strategies are inferred from literature, as existing approaches are categorised, and their advantages and disadvantages are elaborated upon.

**Keywords.** Process Modelling, BPMN, Decision Modelling, Decision Model and Notation, DMN, Integrated Modelling, Hybrid Modelling, Separation of Concerns

## I. INTRODUCTION

An increased interest in separating the decision and process concerns in modeling and mining is present in scientific literature, as illustrated by the vast body of recent literature on Decision Model and Notation [1]–[4]. The first version of the Decision Model and Notation was published in September 2015, while the DMN 1.1 [1] version was made available in June 2016. Numerous tool developers already incorporated DMN modelling in their software packages, making the standard available for industry applications. DMN consists of two levels. Firstly, the decision requirement level in the form of a Decision Requirement Diagram (DRD) is used to portray the requirements of decisions and the dependencies between the different constructs in the decision model. Secondly, the decision logic level is used to specify the underlying decision logic. The standard also provides an expression language FEEL (Friendly Enough Expression Language), as well as boxed expressions and decision tables for the notation of the decision logic. In DMN rectangles are used to depict decisions, corner-cut rectangles for business knowledge models, and ovals to represent data input. The arrows represent information requirements (from data or decisions). DMN is a declarative decision language. Hence, DMN provides no decision resolution mechanism, this is left to the invoking context. The same holds for the processing and storage of

outputs and intermediate results. This is a task of the invoking entity (e.g. a business process).

Despite the adoption of the DMN standards in both industry and academia, a discussion about modelling strategies for process redesign in order to induce decision-awareness is still absent in literature. Additionally, the scientific papers on integrated process and decision management tend to provide a rather simplistic view of decisions as DMN models are fixed to decision points in a process. Hence, decisions are considered a local concern in the process and the DMN model is locally embedded in the decision point as if it were a sub-process. However, when attempting to render processes decision-intelligent, systematic approaches towards decision-driven process re-engineering are necessary. In this paper, we identify modelling strategies for integrated process and decision management based on categorisations of previous works in BPM literature. Decision-centric, process-centric, and process-extraction strategies are identified;

## II. RELATED WORK AND MOTIVATION

### A. Integrating Processes and Decisions

The Separation of Concerns (SoC) and Service-Oriented Architecture (SOA) paradigms offer firm motivation for keeping multi-perspective modelling tasks isolated and founded on a basis which can be used to ensure consistency. With DMN, externalisation of decisions has become a possibility, since decisions can be encapsulated in separate decision models and linked to the invoking context, e.g. a business process. The decision modelling approaches present in process management literature often breach the separation of concerns between control and data flow, hence negatively influencing maintenance and reusability, as pointed out by [2], [5]–[7]. These approaches often hard code and fix the decisions inside processes. Consequently, splits and joins in processes are misused to represent typical decision artifacts such as decision tables. Recently, more attention was given to the separation of process and decision logic. Decoupling decisions and processes to stimulate flexibility, maintenance, and reusability, yet integrating decision and process models is of paramount importance [2], [4], [7], [8]. Hence, the DMN standard can play a vital role in knowledge- and decision-intensive processes [9].

## B. Decision Services

Recent BPM literature moves towards accommodating decision management into the paradigms of SoC [2], [10], [11] and SOA [7], by externalising decisions and encapsulating them into separate decision models, hence implementing decisions as externalised services. Literature proposes several conceptual decision service platforms and frameworks [7], [12], [13] and industry has adopted this trend, as several decision service systems have appeared, e.g. SAP Decision Service Management [14]. This externalisation of decisions from processes provides a plethora of advantages regarding maintainability and flexibility of both process and decision models [2], [3], [7], [11], [15].

However, despite the fact that the integration of decision and process models, as well as decision services have already been studied, scientific literature on strategies and methodologies for integrated process and decision modelling on its own is still lacking. This paper aims at approaching that research gap in the following sections and at providing an overview of possible strategies for the integration of processes and decisions.

## III. INTEGRATED PROCESS AND DECISION MODELLING STRATEGIES

In this section we outline modelling strategies for integrated process and decision modelling. Additionally, we discuss opportunities and limitations of each strategy. The integrated modelling strategies are inferred from existing approaches in literature and the categorisation of these approaches leads to a number of modelling strategies that are concerned with rendering processes decision-adaptive. We distinguish three types of modelling strategies: process-centric, process-extraction, and decision-centric strategies. Figure 1 gives a schematic overview of the modelling strategies that can be applied to redesign processes for decision model compliance.

### A. Process-Centric Approaches

The process-centric approach to decisions is the most prolific in literature [4], [16]–[21]. This approach views decisions as local concerns pertaining to decision points in the process model. An XOR-split in the process is annotated with a decision model explaining the routing behaviour after the decision point. This is a relevant and rather straightforward way to look at decisions in processes. However, the approach convolutes decision logic with routing logic and the distinction between the two is not always clear. Decisions do not only happen at XOR-splits, but can happen anywhere in the process. Furthermore, decisions do not necessarily influence the routing of the cases, but they can impact the process from other perspectives such as the data or the resource perspective. Containing decisions to a specific decision point in the process does not provide the necessary flexibility and reusability of decisions. Rather, the DMN model is used as some sort of sub-process that executes the decision steps. That way, the decision model is simply seen as an ad-on in the process model, instead of being an independent model that encapsulates the actual business rules and decisions. Besides, decision models

pertaining to a single decision point in the process often do not represent the holistic business decision, but only a fragment of the whole decision that is relevant to the specific gateway in the process that the decision model pertains to. Hence, this approach values the process above the decisions and the decisions are seen as tools that the process needs to invoke at certain stages of the process.

Redesigning processes for decision awareness in this process-centric integrated modelling strategy is rather simple and straightforward. The process is not at all concerned with the underlying decision and the redesign effort is twofold: providing the relevant input data for the decision in the process and capturing all possible decision outcomes in the process. The process needs simply to ensure that the decision model has all the necessary inputs. This solves the integration for the input aspect of the decision model, but the output aspect should be considered as well. More precisely, it is necessary that all possible decision outcomes from the decision model are represented in the control flow following the gateway at the decision point. If not all possible outcomes are captured and one of the non-captured outcomes is provided to the process by the decision model, the process is not able to continue the execution. Hence, all decision outcomes of the top-level decision in the decision model should exhaustively be represented in the process control flow. Figure 1 represents the process-centric approach schematically in the bottom-left corner, where the process is placed above the decision model underlying the decision point. The decision model serves as a detailed representation of the local decision made in that particular decision point. Thus, the decision model is somewhat viewed as a sub-process for decision execution.

### B. Process-Extraction Approaches

The process extraction approach also starts from the process model, but does not necessarily only look at decision points. Rather, the approach tries to identify decision constructs in the process model and subsequently, the approach externalises the decision constructs into a separate decision model, thus effectively relieving the process from decision elements. This usually also impacts the process model itself, as the process needs adaptation in order to exclude the externalised decision constructs. This approach was applied in [22]–[25]. A limitation of this approach is that the extracted decision model is strongly dependent on how the process was modelled. Decision constructs can be modelled in a lot of different ways and patterns inside a process, e.g. gateways, activities or events. The way the decisions are modelled inside the process will greatly impact the decision model that is extracted from that process. Thus, the risk is that the extracted decision model is not necessarily representing the true underlying decision logic, but rather a convolution of decision and process logic resulting from the choices made by the modeller during the endeavour of process modelling.

Figure 1 represents the process-extraction strategy in the bottom-right corner. This approach, like the process-centric approach, still starts from the process. However, the decisions

are not contained to a single decision point. Rather, decision constructs are recognised in multiple parts of the process. This strategy is set out to identify those decision constructs in the process and to externalise them into a separate decision model. This is often achieved by constructing mapping and transformation rules, e.g. rules that map decision-rich BPMN constructs to DMN constructs, thus allowing a transformation of parts of a BPMN model into a DMN model [25]. Complications in this strategy mainly result from *inaccurate mappings* or from *irrelevant mappings*. Inaccurate mappings are mappings that do not recognise certain decision constructs within a process model; for instance long distance dependencies between certain input elements and the actual decision being made: a data object at the start of the process can impact a decision near the end of the process and mappings are likely to miss these long distance dependencies. On the other hand, irrelevant mappings map process constructs that are perceived to be related to the decision, but that are in essence not relevant for the decision model at all. For instance, every exclusive gateway in the process is perceived to be part of a decision. However, the difference between process logic and decision logic is of paramount importance to obtain a decision model that represents the true business decisions. Process logic does not belong in such an externalised decision model. Certain gateways will simply guide the cases in the process model and will not be involved in the actual business decision. Hence, this approach does not guarantee a sound decision management.

Redesigning the process for decision-intelligence in this strategy consists out of four steps:

- 1) First, mappings and transformation rules from process constructs to decision constructs are established, e.g. a mapping of BPMN to DMN.
- 2) Second, process constructs that are perceived to relate to a decision are identified in the process.
- 3) Next, the identified decision constructs in the process are captured and encapsulated in a separate decision model.
- 4) Finally, the process is relieved from the perceived decision constructs that were externalised in the previous step, while ensuring that the process is still able to invoke the externalised decisions.

The actual process redesign happens in the final step. Here, the externalised decision constructs are deleted from the process. However, integration between the externalised decision model and the remaining process is necessary to ensure a sound communication between the two models. Like in the process-centric approach, this integration should rely on a sound data management in the process, both in terms of decision inputs and decision outputs, for every decision that is invoked in the process. Unlike in the process-centric approach, where the decision point only invokes the top-level decision of the decision model, the process-extraction approach allows the process to invoke multiple (sub)decisions of the same decision model in multiple stages of the process, provided that the data integration for decision inputs and decision outputs is handled correctly in the process.

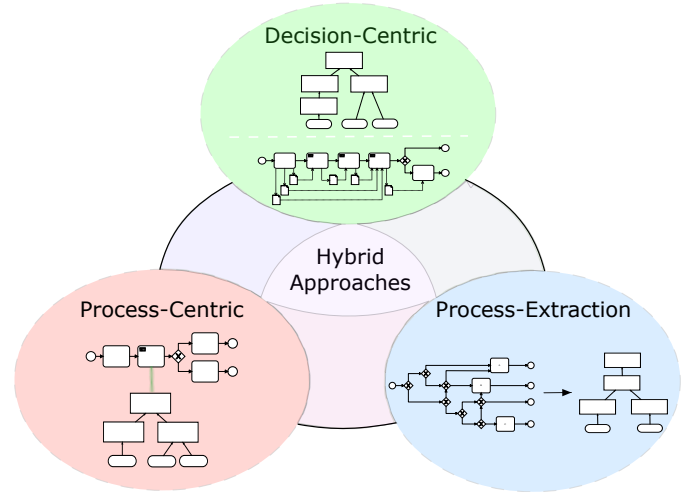


Figure 1: Integrated Modelling Strategies.

### C. Decision-Centric Approaches

Unlike the previous two approaches that both start from the process model, the decision-centric approach starts with the decision model and the process model is constructed afterwards in such a way that it is automatically consistent with the provided decision model. This holistic decision approach has been described in [2], [6]–[8], [11]. Unlike the two previous approaches, this approach does not depend on the process model and the process model does not influence the construction of the decision model. Rather, the decision model that represents the actual underlying business decisions is constructed without convolution of the decision logic with the routing logic of the process. A limitation of this approach is that it completely refactors the process models that need to invoke the initially constructed decision model. Hence, the process models will need to be adapted to be consistent with the decision model, as the process model should be concerned about the correct invocations of the decisions, i.e. the process model needs to provide the relevant data inputs for the decision model and needs to take care of data storage, and data and decision outcome propagation within the process model or even across multiple process models.

Thus, this decision-centric approach differs significantly from the two previous approaches. Unlike the process-first approach, decisions are put above the process as the decision is modelled first and the process is constructed later. Furthermore, unlike the process-extraction approach, the process is constructed or altered around the decisions in such a fashion that it complies to the decision model, rather than the decision model being built around the process constructs that are perceived to belong to decision making. Hence, the decision-centric strategy is fundamentally different as the focus here is on modelling the true underlying business decisions that can be invoked by any process that needs the outcome of those decisions, given that the invoking process model complies with the decision model, i.e. that a sound integration between the two models exists.

Redesigning the process for decision-awareness in the decision-centric strategy happens as follows:

- 1) First, a decision model is constructed containing the decision logic of the actual business decisions.
- 2) Next, the process is remodelled around the decisions it wishes to invoke during process enactment. When redesigning the process special interest should be given to a sound integration between the process and decision model. Table I gives an overview of **Five Principles** for integrated **Process and Decision Modelling (SPDM)** [2] that ensure a sound process-decision integration according to the decision-centric strategy. The modelling principles are concerned with the correct decision input and output data management, as well as with which decision constructs in the form of subdecisions to explicitly include in the process model and which decision constructs to exclude from the process model. A step wise approach to adhere to these modelling principles is provided in [2].

Principles for integrated process-decision modelling (SPDM)
<b>P1:</b> Include <i>all</i> necessary <i>decision outcomes</i> in the process
<b>P2:</b> Exclude <i>decision logic</i> and cascading XOR-splits in the process
<b>P3:</b> Include <i>only subdecisions</i> that directly <i>influence</i> the process
<b>P3.1:</b> Include <i>subdecisions</i> whose <i>results</i> are used in process
<b>P3.2:</b> Include <i>subdecisions</i> that <i>affect</i> the process <i>control flow</i>
<b>P3.3:</b> Exclude <i>subdecisions</i> that are or <i>irrelevant</i> to the process
<b>P4:</b> Include <i>decision hierarchy</i> in decision activity modelling
<b>P5:</b> Include <i>input data</i> and <i>intermediate results</i>

Table I: SPDM [2]

Note that Figure 1 also indicates the possibility of hybrid strategies that combine the previously discussed approaches into a single eclectic strategy. Organisations are likely to use mixed approaches as temporary solutions in their transition towards a holistic decision management approach. This is due to the fact that adapting existing processes to a newly modelled holistic decision model is a time-consuming endeavour. The switch from a not fully decision-centric to a decision-centric approach is not instantaneous, hence the organisation is likely to employ a mixed approach. However, no hybrid approaches were identified in scientific literature.

#### IV. CONCLUSION

This paper presents modelling strategies for integrated process and decision modelling. The strategies are inferred from literature and categorised into process-centric, process-extraction, and decision-centric approaches. We discussed the advantages and disadvantages of the proposed strategies. In future work, we will further investigate how integrated process and decision modelling influences the process and process redesign.

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